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Pediatric Distal Forearm Fracture Epidemiology in Malmö, Sweden—Time Trends During Six Decades

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Abstract

Background The distal forearm fracture is the most common fracture in children. To allocate health care resources and evaluate if prevention strategies have been successful, it is essential to monitor changes in the epidemiology of common fractures.

Methods Our hospital serves a city in which year 2006 included 276,244 inhabitants (49,664 <17 years of age). Through the hospital archives, we identified fractures sustained by individuals younger than 16 years during 2005 and 2006 and compared these with previous collected and published data from the same area and hospital for the period 1950 to 1994. We used official population data to estimate period-specific fracture rates and age and gender standardized time trends. We report rates as number of fractures per 100,000 person-years and changes between periods as rate ratios (RR) with 95% confidence intervals (CIs).

Results We identified 521 distal forearm fractures, corresponding to a crude fracture incidence of 564/100,000 person-years (boys 719; girls 401). Age-adjusted fracture incidence was 70% higher in boys than in girls (RR 1.7; 95% CI 1.3–2.3). The age- and gender-adjusted hand fracture incidence was 40% higher in 2005–2006 than in 1950/1955 (RR 1.4; 95% CI 1.2 to 1.8) but no higher than 1993–1994 (RR 1.1; 95% CI 0.9–1.3). Fracture etiology of 2005 to 2006 included sports injuries in 41% and traffic accidents in 11% of the cases, while sports injuries explained 37% and traffic accidents 18% in 1950 to 1955.

Conclusion In 2005 to 2006, we found higher rates in boys and higher overall rates compared with the 1950s but no significant differences compared with the rates in 1993 to 1994. Future studies should include patient-specific data to unravel causal factors.

Level of evidence This is a Level III b study.

Keywords
- children
- boys
- girls
- epidemiology
- etiology
- distal forearm
- fractures
- trends

One-fourth of all children sustain traumatic injuries annually that require treatment in emergency departments.[1,2] Around a fifth of these have fractures.[3,4] As results suggest, half of all boys and a third of all girls sustain fractures during childhood.[5,6] The distal forearm fracture accounts for around one-third of these fractures,[5–10] with boys having higher incidences than girls and girls having an earlier peak incidence than boys.[5,6,11] As there has been time trend change in pediatric fracture epidemiology during last decades,[5,6,10–19] there is a need to update fracture epidemiology, to be able to adequately allocate health care resources. It is also essential to update etiology data, to identify emerging fracture-prone activities in need of prevention, and evaluate if advocated prevention strategies have been effective.

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The aim of this study is to report distal forearm fracture epidemiology/etiology in children in 2005 to 2006 and with use of published data from the same area[5,11] evaluate time trends in age- and gender-standardized fracture incidences from 1950/1955 to 2005–2006.

Patients and Methods

In 2006, our city had a population of 276,244 (46,429 <16 years of age).[20,21] The city has only one emergency hospital that provides the trauma care within the city, and all medical charts, referrals, radiographs, and reports are saved in the hospital archives.[22] Until 2001, radiographs were sorted according to anatomical region, year of injury, and diagnosis, making it possible to collect data on all verified fractures. This archive has been used to collect pediatric fracture data in residents aged <16 years during the years 1950, 1955, 1960, 1965, 1970, 1975 to 1979,[5] and 1993 to 1994,[11] previously reported as crude incidence rates, without age and gender standardization.[5,11] It is therefore unclear if identified time trends from 1975–1979 to 1993–1994 are the result of changes in demography and/or factors beyond this.

In 2001, the radiographic archive was replaced by a digital archive. This archive includes all radiographs in the southern part of the country, classified according to patient-specific personal identity numbers. To identify pediatric fracture cases in 2005 to 2006, we used the digital in- and outpatient diagnosis records at the Emergency Department and the Departments of Orthopedics, Hand Surgery, and Otorhinolaryngology. We included records that fulfilled the following criteria: (1) International statistical classification of diseases and related health problems: 10th revision (ICD-10) fracture diagnosis: S02.3–S02.4, S02.6–S02.9, S12.0–S12.2, S12.7, S22.0, S32.0–S32.8, S42.0–S42.9, S52.0–S52.9, S62.0–S62.8, S72.0–S72.9, S82.0–S82.9, and S92.0–S92.9; (2) age <16 years at the time of the fracture; and (3) city resident at the time of the injury.

We identified 4,459 visits with a fracture diagnosis, 1,563 with fractures of the forearm (ICD code S52. –) and 1,143 with fracture of the distal forearm (ICD code S52.5–S52.6). We reviewed medical charts, referrals, and reports to register type of fracture and trauma etiology. In unclear cases and all cases where the fracture involved the diaphysis or the distal part of the forearm, we rereviewed the radiograph to achieve the right ICD classification. A fracture of the distal forearm was then defined as a fracture of the radius, ulna, or both radius and ulna located distal to the diaphyseal region. The point where the cortex attained a constant thickness was then defined as the limit between the metaphysis and diaphysis.[5,11] Since all visits were reviewed, we could exclude follow-up visits after an index fracture visit, thus avoiding double counting of fractures. Patients who received emergency treatment in other hospitals are in our country, as standard, referred to the home hospital for follow-up evaluation, a visit when these fractures are captured in the archives.

We collected pediatric fracture data from 2005 to 2006, following the same protocol as in previous studies,[5,11] thus registering multiple fractures on the same patient as independent fractures. We registered refractures (fractures of the same area of the same bone that occurred within one year) as new fractures and included data on patient age and gender, number of fractures, date of the fracture, fractured region/regions and side, and fracture etiology.

To validate the new fracture ascertainment system, one author (VL) performed a search in the digital radiological archive for all pediatric skeletal radiographs, independent on the reason for the referral, at the radiology department of the hospital from January 1, 2005, to February 28, 2005 (n = 103). The same researcher then conducted a second search by use of the same search criteria in the digital in- and outpatient diagnosis records archive. This second search also identified 103 fractures. One hundred fractures were identified by both methods; each method alone identified 103 fractures, while the two methods combined identified 106 fractures. Each method thereby missed three fractures, a miscalculation rate of 3%.

We used Microsoft Excel 2010 for data management and statistical calculations. We grouped the previously reported distal forearm fracture data in 5 periods (1950/1955, 1960/1965, 1970/1975, 1976–1979, and 1993–1994) and estimated the total and gender specific incidence rates of distal forearm fractures during each period. Results are presented as number of fractures, mean fracture incidences per 100,000 person-years, and as proportions (%) of all fractures. The population at risk (i.e., city residents <16 years) during each period was available through official records.[20] Age- and gender-standardized rates were calculated through direct standardization, with the average pediatric city population (in one-year classes) during the study period as reference. Differences in rates were calculated as rate ratios (RR) by chi-square distribution with 95% confidence intervals (CIs). $p < 0.05$ was considered a statistically significant difference. The study was approved by the ethical committee, Lund University (reference number 2010/191) and was conducted in accordance with the Declaration of Helsinki.

Results

Fracture Epidemiology 2005–2006

During 2005 to 2006, we identified 1,692 fractures (1,119 in boys and 573 in girls) sustained in 1,615 children.[6] Among these, there were 521 fractures of the distal forearm (341 in boys and 180 in girls), sustained in 511 children (31% of all fractures; 30% in boys and 31% in girls). Ten boys had two fractures each during the observed period, four at two different occasions and six bilateral at the same trauma event.

Of the distal forearm fractures, 448 (86%) were isolated distal radius fractures (85% in boys and 88% in girls), 71 (14%) fractures of both the distal radius and ulna (15% in boys and 11% in girls), and two distal ulna fractures (one in boys and one in girls). Of the distal radius fractures, 474 (91%) involved the metaphysis (91% in boys and 92% in girls) and 45 (9%) involved the physis (9% in boys and 8% in girls).

Table 1 Distal forearm fracture epidemiology in children in our city during six periods 1950–2006

Fractures of the distal forearm in children aged <16 years in our city, years 1950–2006							
		1950/1955	1960/1965	1970/1975	1976–1979	1993–1994	2005–2006
Number of of fractures	All children	361	389	391	790	421	521
	Boys	211	230	223	487	232	341
	Girls	150	159	168	303	189	180
Crude incidence	All children	387	376	409	491	512	564
	Boys	443	433	455	591	549	719
	Girls	328	315	360	387	474	401
Age-adjusted incidence	All children	397	371	401	468	535	573
	Boys	454	427	447	557	577	721
	Girls	328	315	360	387	474	401

Note: Data are presented as number of fractures, crude incidence, and age-adjusted incidence per 100,000 person years.

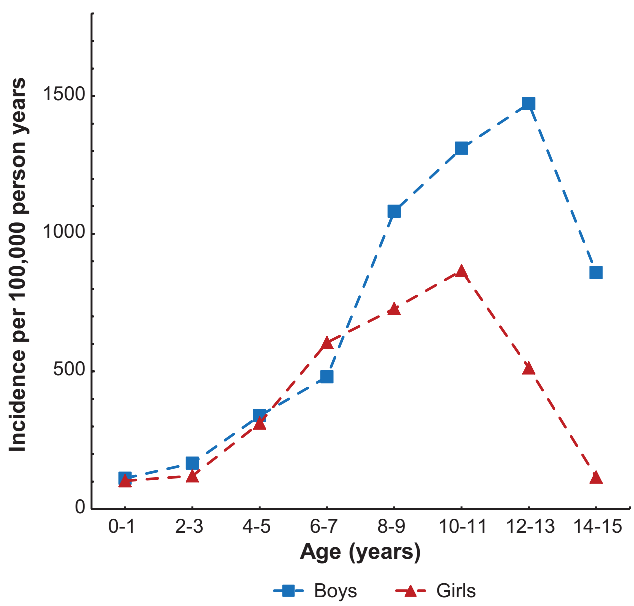

Fig. 1 Gender- and age-specific distal forearm fracture incidence in children during the period 2005 to 2006. Data are provided as number of fractures per 100,000 person years.

The crude incidence of distal forearm fractures was 564/100,000 person-years (719 in boys and 401 in girls), with 70% higher age-standardized incidence in boys than in girls (RR 1.7; 95% CI 1.3–2.3) (►**Table 1**). Left side fractures were 55% more common than right side fractures (RR 1.6; 95% CI 1.3–1.9). Left side fractures were more common both in boys (RR 1.4; 95% CI 1.1–1.7) and in girls (RR 1.9; 95% CI 1.4–2.6). The crude incidence of distal forearm fractures increased with aging in both genders, until age 10 to 11 in girls and 12 to 13 in boys (►**Fig. 1**). After age 8 to 9, the age-specific fracture incidence in boys was higher than in girls (►**Fig. 1**).

Time Trends from 1950/1955 to 2005–2006

The crude distal forearm fracture rate was 46% higher in 2005 to 2006 than in 1950/1955 (RR 1.5; 95% CI 1.3–1.7) and the age- and gender-standardized fracture 44% higher (RR 1.4; 95% CI 1.2–1.8) (►**Tables 1** and **2**).[5,11]

Table 2 Changes in crude and age-adjusted incidence of distal forearm fracture incidence in all children, from 1950/1955 to 1993–1994, from 1950/1955 to 2005–2006 (entire period), and from 1993–1994 to 2005–2006 (most recently evaluated periods)

Denominator	1950/1955		1993–1994
Nominator	1993–1994	2005–2006	2005–2006
Unadjusted	**1.3 (1.1–1.5)**	**1.5 (1.3–1.7)**	1.1 (0.97–1.3)
Age adjusted	**1.3 (1.1–1.6)**	**1.4 (1.2–1.8)**	1.1 (0.9–1.3)

Note: Differences are presented as rate ratios with 95% confidence intervals within brackets. Statistically significant changes are represented in bold.

Gender-specific evaluation revealed similar trends from 1950/1955 to 1993–1994 (►**Fig. 2A, B**; ►**Supplement Table 1** [online only]), while boys in 2005 to 2006 had 31% higher crude incidence than in 1993 to 1994 (RR 1.3; 95% CI 1.1–1.5) and 20% higher age-adjusted incidence (RR 1.2; 95% CI 0.98–1.6) while there in girls was no statistically significant differences between the periods (►**Fig. 2A, B**; ►**Supplement Table S1** [online only]).

Boys reached the highest distal forearm fracture incidence at the same ages in 2005 to 2006 as in 1950/1955 (►**Fig. 3A**), while girls in 2005 to 2006 reached their peak incidence 1 to 2 years earlier than in 1950/1955 (►**Fig. 3B**). Furthermore, girls reached peak incidence before the boys in all evaluated periods. The proportion of distal forearm fractures among all fractures in boys and in girls during the different evaluated periods, is shown ►**Fig. 4**.

Fracture Etiology 2005–2006

Among the patients where trauma type was possible to identify, 41% occurred following a sport injury (45% in boys and 33% in girls), 32% following a playing accident (27% in boys and 41% in girls), and 11% following traffic injuries (►**Table 3**). The proportion of traffic accidents and home accidents as fracture etiology was in 2005 to 2006 lowest of all evaluated periods (►**Table 3**).

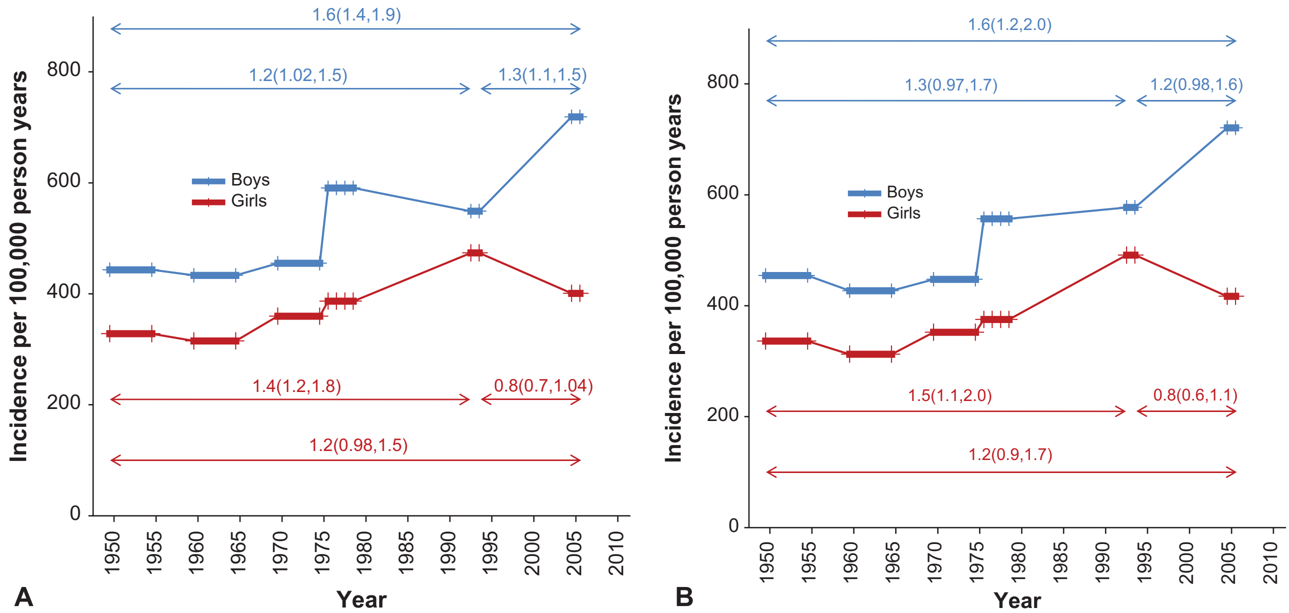

Fig. 2 (A) Crude gender-specific incidence of distal forearm fractures during six evaluated periods, 1950 to 2006. Data are provided as number of fractures per 100,000 person-years. The periods reported are indicated with horizontal thick lines between period start and end while individual evaluated years are indicated by thin crosses. Comparisons between different periods are provided as rate ratios with 95% confidence interval (CI). Horizontal arrows below the rate ratios indicate the periods compared. (B) Age-adjusted, gender-specific incidence of distal forearm fractures during six evaluated periods, 1950 to 2006. Data are provided as number of fractures per 100,000 person-years. The periods reported are indicated with horizontal thick lines between period start and end while individual evaluated years are indicated by thin crosses. Comparisons between different periods are provided as rate ratios with 95% CI. Horizontal arrows below the rate ratios indicate the periods compared.

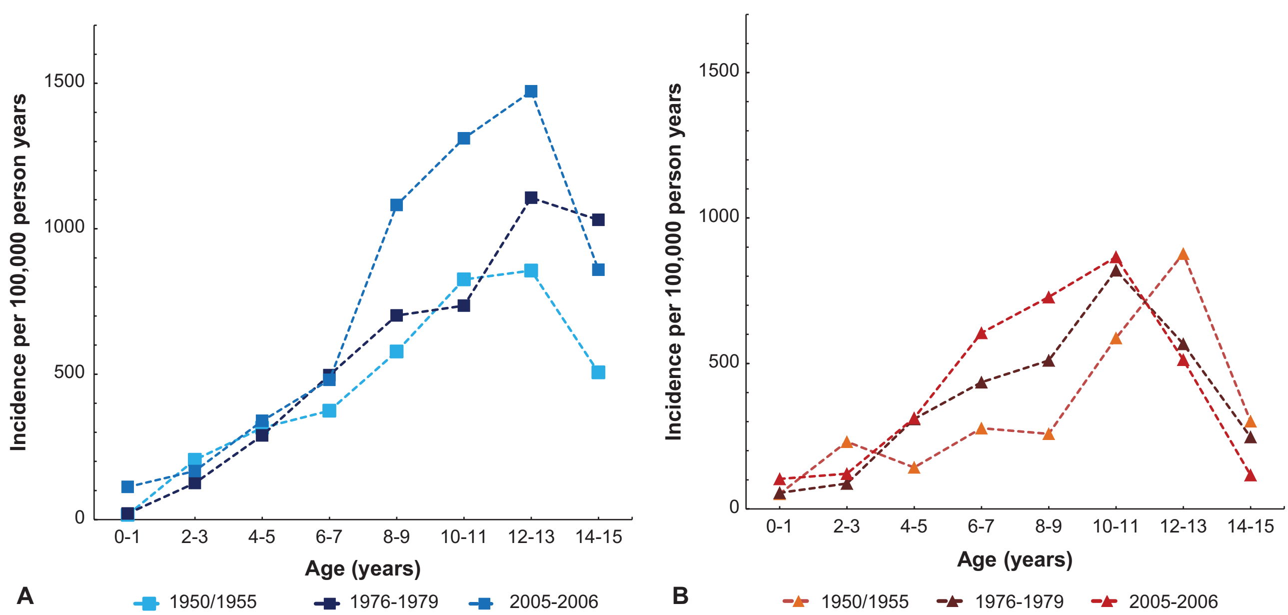

Fig. 3 (A) The age-specific incidence of distal forearm fractures in boys during the three periods 1950/1955 (study start), 1976–1979 (middle of the study period), and 2005–2006 (study end). Data are provided as incidences per 2-year age class. (B) The age-specific incidence of distal forearm fractures in girls during the three periods 1950/1955 (study start), 1976–1979 (middle of the study period), and 2005–2006 (study end). Data are provided as incidences per 2-year age class.

Discussion

Distal forearm fractures contribute to about one-third of all pediatric fractures, are more common in the left than the right side, more common in boys than in girls, and have a peak incidence in ages 10 to 11 years in girls and 12 to 13 years in boys. Both the crude and the age-adjusted pediatric distal forearm fracture incidence are higher in 2005 to 2006 than in 1950/1955. The proportion of distal forearm fractures due to traffic and home accidents was lowest in 2005 to 2006 of all evaluated periods.

The crude pediatric distal forearm fracture incidence in Malmo, Sweden for the period 2005 to 2006 (564/100,000 person-years in 2005–2006) was slightly higher compared

Table 3 Etiology of distal forearm fractures in all children during the periods 1950/1955, 1960/1965, 1970/1975, 1976–1979, 1993–1994, 2005–2006 as well as in boys and girls separately in 2005–2006

Environmental factors	1950/55	1960/65	1970/75	1976–79	1993–94	2005–2006		
	All children					All children	Boys	Girls
Known	**45.2%**	**51.7%**	**57.0%**	**56.6%**	**65.3%**	**74.7%**	**73.9%**	**76.1%**
Unknown	**54.8%**	**48.3%**	**43.0%**	**43.4%**	**34.7%**	**25.3%**	**26.1%**	**23.9%**
Home	**7.4%**	**6.5%**	**9.9%**	**3.8%**	**6.5%**	**1.8%**	**2.0%**	**1.5%**
Day nursery	**0.0%**	**0.0%**	**1.3%**	**1.6%**	**1.5%**	**1.3%**	**0.8%**	**2.2%**
School	**9.8%**	**8.5%**	**13.0%**	**7.8%**	**8.0%**	**11.1%**	**10.7%**	**11.7%**
Work	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Traffic accidents	**17.8%**	**13.9%**	**16.1%**	**13.9%**	**15.6%**	**10.8%**	**11.5%**	**9.5%**
Bicycle accidents	17.2%	9.5%	12.1%	12.1%	13.5%	9.8%	9.9%	9.5%
Pedestrian hit by vehicle	0.0%	3.0%	1.3%	0.4%	0.0%	0.3%	0.4%	0.0%
Moped, motorcycle	0.0%	0.5%	2.2%	0.7%	1.5%	0.8%	1.2%	0.0%
Car passenger	0.6%	0.5%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%
Other	0.0%	0.5%	0.4%	0.0%	0.7%	0.0%	0.0%	0.0%
Playing accidents	**26.4%**	**30.8%**	**22.4%**	**37.6%**	**32.4%**	**31.6%**	**26.6%**	**40.9%**
Playground	8.6%	7.5%	4.9%	10.7%	12.7%	13.9%	8.3%	24.1%
In-lines, skateboard	0.0%	0.0%	0.9%	8.9%	5.1%	9.8%	9.5%	10.2%
Sledge, other “snow”	1.2%	0.0%	2.2%	2.7%	1.1%	1.8%	2.0%	1.5%
Other play accidents	16.6%	23.4%	14.3%	15.2%	13.5%	6.2%	6.7%	5.1%
Sport accidents	**37.4%**	**39.3%**	**35.4%**	**34.2%**	**34.5%**	**40.9%**	**45.2%**	**32.8%**
Ball-game	6.7%	9.5%	10.8%	15.2%	13.5%	27.8%	34.5%	15.3%
Ice-hockey, skating	27.6%	21.9%	17.0%	10.1%	10.9%	3.9%	5.2%	1.5%
Gymnastics and athletics	0.6%	3.5%	1.3%	0.7%	2.9%	2.3%	1.6%	3.6%
Horse accidents	1.2%	2.5%	4.0%	4.7%	4.0%	3.1%	0.4%	8.0%
Wrestling, boxing, etc.	0.6%	0.5%	1.3%	2.0%	0.7%	0.5%	0.4%	0.7%
Skiing	0.6%	1.5%	0.9%	1.3%	1.8%	3.3%	3.2%	3.6%
Other	0.0%	0.0%	0.0%	0.2%	0.7%	0.0%	0.0%	0.0%
Fights	**0.6%**	**1.0%**	**1.3%**	**0.0%**	**0.7%**	**2.6%**	**3.2%**	**1.5%**
Other	**0.6%**	**0.0%**	**0.4%**	**1.1%**	**0.7%**	**0.0%**	**0.0%**	**0.0%**

Note: Data are presented as the proportions (%) of fractures associated with each specific activity in relation to all fractures where the associated activity was known.

with that in Helsinki, Finland, for the year 2005 (496/100,000 person-years)[17] and in the Stockholm region in Sweden, 2004 to 2010 (535/100,000 person-years),[19] but lower than in the Umea region in the north of our country, year 2006 to 2007 (592/100,000 person-years),[13] and lower than in the southern region of our country, year 1999 to 2010 (634/100,000 person-years).[14] The discrepancies may be explained by different fracture ascertainment methods, with some studies including only objectively registered fractures[13,15–17] while others use register data,[10,12,14] different included age spans,[10,12–16] different evaluated periods,[10,12,13,19] inclusion of only urban or also rural populations,[14,23] inclusion of populations with different ethnic background,[14,24–27] and/or inclusion of regions with or without extended periods with icy and slippery conditions,[10,12–15] all factors known to influence fracture rates. However, the data highlight the possibility that there are differences in pediatric fracture rates in different regions, supported by data from the United Kingdom that infer fracture incidence rate ratios vary from 1.0 to 1.7 in different county regions compared with London.[10]

Distal forearm fractures are in most studies reported higher in boys than in girls.[5,11–14,16,17,19] We support this notion when finding an age-standardized boy to girl ratio of 1.7, similar to that reported in the Umea region in Sweden[13] in Helsinki, Finland,[17] but higher than in southern Sweden[14] in Stockholm, Sweden[19] and in the United Kingdom.[10] These gender differences are usually referred to as differences in risk-taking behavior, spare time activities, and skeletal maturity. Our data also support that girls have a less prominent peak fracture incidence than boys and that girls reach their peak incidence 1 to 2 years before boys.[5,11,19] These

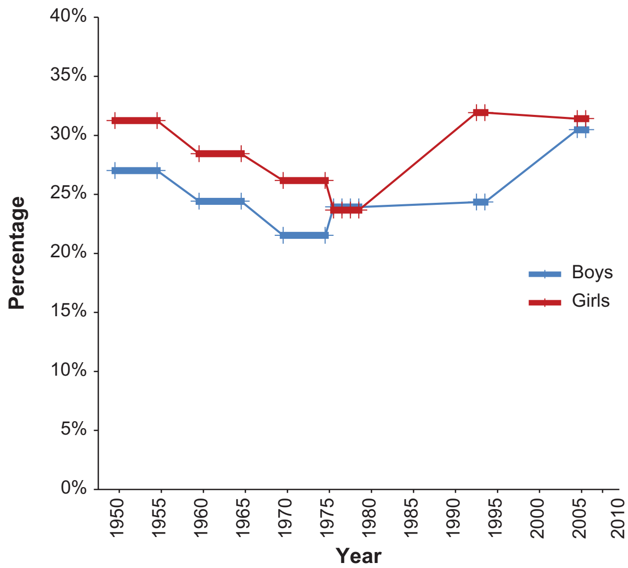

Fig. 4 Proportion of distal forearm fractures of the total fracture burden in boys and girls during six evaluated periods 1950 to 2006. The periods reported are indicated with horizontal thick lines between period start and end while individual evaluated years are indicated by thin crosses.

findings are usually attributed to the 1 to 2 years earlier pubertal growth spurt in girls than in boys, a period when peak velocity of bone growth precedes peak bone mineralization,[28,29] resulting in a temporary weaker bone.[30,31] The earlier pubertal development in children of today compared with decades ago[32] would then also explain why girls in 2005 to 2006 reached the peak distal forearm fracture incidence at a younger age than in 1950/1955 (►**Fig. 3**).

The age-adjusted distal forearm fracture incidence was 44% higher in 2005 to 2006 than in 1950/1955 (in boys 59% higher and in girls 22% higher [not reaching statistical significance]). The same trend was found between the two last evaluated periods, with 7% higher incidence in 2005 to 2006 than in 1993 to 1994 (RR 1.1[0.97, 1.3]), with possible diverging trends in boys (RR 1.2 [0.98, 1.6]) and in girls (RR 0.8 [0.6, 1.1]). That there during the last decades actually has been an increase in the total pediatric distal forearm fracture incidences is supported by data from all southern Sweden with an increased incidence between 1999 and 2010,[14] in Finland between 1985 and 2005,[17] in the Netherlands between 1997 and 2009,[12] and in the United States between 1969–1971 and 1999–2001.[12,16] These studies do not address any possible gender differences in the recent time trends, highlighting the need of larger sex-specific studies during the recent years to verify or refute our data.

Etiology data indicate that prevention in traffic and home environment have positively influenced time trends in pediatric fracture incidence.[33,34] Time trends in lifestyle, such as less physical activity among children, may also influence time trends. Swedish children have reduced their everyday physical activity during recent decades, instead spending more time in front of monitors,[35] and low levels of physical activity is a risk factor for fractures.[36,37] The proportion of children with foreign background in our city was in 2005 to 2006 also higher than during previous decades,[38,39] another difference that could have influenced time trend.[26,27,40]

Study strengths include the epidemiology and etiology data from a well-defined cohort during six decades. Inclusion of only objectively verified fractures, without double counting due to multiple visits, is another strength. Weaknesses include the changed fracture ascertainment method in 2001. However, the validation examination indicated that only 3% of fractures were misclassified. Another weakness is that fractures in children living within the catchment but treated elsewhere would not be registered. This is probably a minor problem since fractures primarily treated in other hospitals usually referred to the home hospital for follow-up visits. Another confounder could be that individuals, decades ago, were less prone to seek medical advice and that doctors at that time were more hesitant to send patients to X-ray examinations than today, then missing actual fractures. If this actually was the case is impossible to clarify today. It had also been beneficial to be able to adjust for demographic changes in ethnicity within the catchment area and an available larger sample size, especially in the subgroup analyses, reducing the risk of conducting type II error. Finally, the larger proportion of missing fracture etiology historically than at the last follow-up, is another limitation and the reason to why we refrained from statistical analysis of time trend changes in etiology.

In conclusion, the age-adjusted incidence rate of distal forearm fractures in children was 60% higher in 2005 to 2006 than in 1950/1955, with also a trend of being higher than that in 1993 to 1994. The possible diverging time trends for boys and girls since 1993 to 1994 call for further pediatric fracture epidemiological surveys.

Note

The study was approved by the ethical committee, Lund University (reference number 2010/191), and was conducted in accordance with the Declaration of Helsinki.

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Conflict of Interest

None declared.

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